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Impact of Heterogeneous Fracture Aperture on the Well Productivity of Deformable Fractured Porous Media

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Multi-scale modeling in poroelasticity: Computational homogenization and Numerical Model Reduction

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In heterogeneous porous media, hydro-mechanical coupling between solid matrix and pore fluid under mechanical loading induces fluid pressure gradients and, accordingly, redistribution of fluid in the pore space in terms of a Darcy-type pore pressure diffusion.

In this contribution, we put particular emphasis on pore pressure diffusion in porous media on several length scales. To this end, we interpret the heterogeneous porous rock as a multi-scale material. We coin the name meso-scale for the length scale of heterogeneities (fractures, patchy saturation, …) which are much larger than the microscopic pores and grains. The hydro-mechanical loading and the overall structural response are assumed to act and to be measured on the macro-scale (separation of scales between micro-, meso- and macro-scale).

In the case of a purely mechanical macroscopic loading, we observe a local redistribution of pore fluid without overall fluid transport. In other words, the diffusion length is, in this case, defined by the typical length of the mesoscopic heterogeneities. Thus, the macroscopic reaction is of viscoelastic nature. If, however, a hydro-mechanical loading is applied on the macro-scale, local fluid redistribution in the pore space is superimposed with a macroscopic fluid transport. This non-local interaction results in an overall poro-viscoelastic material behavior.

In this contribution, we investigate both, the local and the non-local scenario, by computational homogenization. Starting from [1,2] we develop a Numerical Model Reduction (NMR) technique similar to the Nonuniform Transformation Field Analysis (NTFA) to identify the macroscopic (poro-)viscoelastic properties by a set of ("offline") training computations. Our machine learning algorithm allows us to establish a reduced FE^2 scheme to solve macroscopic boundary value problems with full mesoscopic resolution in a numerically efficient and reliable way.

Procter and Gamble Student poster award:

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1 Jänicke, R., F. Larsson, H. Steeb, & K. Runesson [2016]. 'Numerical identification of a viscoelastic substitute model for heterogeneous poroelastic media by a reduced order homogenization approach.' Comp. Meth. Appl. Mech. Eng., 298, pp. 108–120.
2 Jänicke, R., F. Larsson, & K. Runesson [2018]. 'Identification of viscoelastic properties from numerical model reduction of pressure diffusion in fluid-saturated porous rock with fractures.' Comp. Mech., DOI 10.1007/s00466-018-1584-7. **Acceptance of Terms and Conditions**:

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Impact of Heterogeneous Fracture Aperture on the Well Productivity of Deformable Fractured Porous Media

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Several hydrocarbon production wells in the North Sea reservoirs suffer from productivity reduction during primary production. Since the affected reservoirs are highly fractured, closure of natural/induced fractures around wells, due to an increase in effective stress is expected to be one of the main reasons for this reduction. Traditionally, the fracture conductivity is determined by its aperture through a cubic law 1. While the fracture aperture is commonly assumed either constant or uniformly distributed, it is well-known that the aperture distribution is heterogeneous and changes with varying contact stress at each point on the fracture surface. This heterogeneous aperture field can affect the flow performance, and fracture aperture evolution due to thermo-poroelastic stresses 2. Moreover, variance, prior distribution, and correlation length, which are used to populate the heterogeneous field, can further enhance this effect 3. Hence, this study aims to investigate and highlight the impacts of fracture aperture variation, including initial stage and deformed behaviour, on the well productivity through a conceptual steady-state single-fracture reservoir.

Coupled solid deformation and fluid flow in porous media is modelled utilising Complex Systems Modelling Platform (CSMP), an object-oriented application programme interface [4], 5. The investigation is separated into three main parts: (i) the effect of variance, (ii) the effect of prior distribution length, and (iii) the effect of correlation length/angle on well productivity index. Moreover, the comparison among the calculation of the well productivity using the homogeneous, heterogeneity aperture field, and its arithmetic average is also investigated. Taking into consideration the limitations and assumptions made in this study, the following findings are drawn: (i) well productivity tends to be higher when the heterogeneity aperture field is introduced than the homogeneous and arithmetic average ones, (ii) this effect is enhanced when the variance is increased, (iii) there is not much difference between the well productivity results when different prior distributions, i.e. uniform, normal, and log-normal distributions, are utilised, (iv) the increase in the correlation length that perpendicular to the well direction enhances the productivity of the system, and (v) the increase in the correlation length that parallel to the well direction hinders the productivity of the system.

Procter and Gamble Student poster award:

I would like to compete in the Procter and Gamble Student award **References**:

1 J. Jaeger, N. Cook, and R. Zimmerman, Fundamentals of Rock Mechanics, 4th ed. Wiley-Blackwell, 2010.
2 B. Guo, P. Fu, Y. Hao, C. A. Peters, and C. R. Carrigan, "Thermal drawdown-induced flow channeling in a single fracture in EGS," Geothermics, vol. 61, pp. 46–62, May 2016.
3 T. Kadeethum, S. Salimzadeh, and H. Nick, "Investigation on the Productivity Behaviour in Deformable Heterogeneous Fractured Reservoirs," in 2018 International Symposium on Energy Geotechnics, 2018.
[4] H. M. Nick and S. K. Matthäi, "A hybrid finite-element finite-volume method with embedded discontinuities for solute transport in heterogeneous media," Vadose Zo. J., vol. 10, no. 1, pp. 299–312, 2011.
5 S. Salimzadeh, A. Paluszny, H. M. Nick, and R. W. Zimmerman, "A three-dimensional coupled thermo-hydro-mechanical model for deformable fractured geothermal systems," Geothermics, vol. 71, pp. 212–224, Jan. 2018. **Acceptance of Terms and Conditions**:

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A Mixed-dimensional Discontinuous Galerkin Method for Coupled Flow and Transport in Fractured Porous Media

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